Global Ocean Evaporation:
How Well Can We Estimate Interannual to Decadal Variability?

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(Oral Presentation Preferred)

Evaporation from the world's oceans constitutes the largest component of the global water balance. It is important not only as the ultimate source of moisture that is tied to the radiative processes determining Earth's energy balance but also to freshwater availability over land, governing habitability of the planet.

Here we focus on variability of ocean evaporation on scales from interannual to decadal by appealing to three sources of data: the new MERRA-2 (Modern-Era Retrospective analysis for Research and Applications -2); climate models run with historical sea-surface temperatures, ice and atmospheric constituents (so-called AMIP experiments); and state-of-the-art satellite retrievals from the Seaflux and HOAPS (Hamburg Ocean-Atmosphere Parameters and Fluxes from Satellite) projects. Each of these sources has distinct advantages as well as drawbacks. MERRA-2, like other reanalyses, synthesizes evaporation estimates consistent with observationally constrained physical and dynamical models—but data stream discontinuities are a major problem for interpreting multi-decadal records. The climate models used in data assimilation can also be run with lesser constraints such as with SSTs and sea-ice (i.e. AMIPs) or with additional, minimal observations of surface pressure and marine observations that have longer and less fragmentary observational records. We use the new ERA-20C reanalysis produced by ECMWF embodying the latter methodology. Still, the model physics biases in climate models and the lack of a predicted surface energy balance are of concern. Satellite retrievals and comparisons to ship-based measurements offer the most observationally-based estimates, but sensor inter-calibration, algorithm retrieval assumptions, and short records are dominant issues. Our strategy depends on maximizing the advantages of these combined records.

The primary diagnostic tool used here is an analysis of bulk aerodynamic computations produced by these sources and uses a first-order Taylor series analysis of wind speed, SST, near-surface stability and relative humidity variations

around climatology to gauge the importance of these components. We find that the MERRA-2 evaporation record is strongly influenced by the availability of wind speed and humidity from passive microwave imagers beginning in the late 1980s as well as by the SST record. The trend over the period 1980 to present is nearly 10%. AMIP or the ERA-20C trends are much smaller. We find that ENSO-related signals involving both wind speed and thermodynamic variability remain the primary signal in the latter and are confirmed by satellite retrievals. We present uncertainty estimates based on the various data sources and discuss the implications for GEWEX water and energy budget science challenges.